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(54) Method of forming halftone dots

(57) Halftone dots are formed by employing a halftone-dot forming template having a plurality of divided minute grid elements with respective predetermined threshold levels assigned thereto, and comparing the signal level of an image signal with the threshold level of each of the grid elements. There is provided a composite halftone-dot forming template composed of two, Fig. 3, or more (*n*) selectable halftone-dot forming templates arranged side by side. The threshold pattern templates of the composite halftone-dot forming template are selected from a template memory according to the characteristics of a photolectric transducer scanning an original, the screen ruling, the screen angle, and other factors. The threshold levels of the respective grid elements of the composite halftone-dot forming template are of different values from each other, those grid elements the difference between which corresponds to one threshold gradation belonging to different ones, respectively, of the halftone-dot forming templates.

FIG. 3

121	107	85	49	65	87	109	123	122	108	86	52	78	88	110	124
105	83	73	33	41	57	89	111	106	84	60	26	44	70	90	112
81	63	25	9	17	27	75	91	82	68	34	10	18	36	62	92
71	47	23	1	3	11	35	51	76	42	24	2	4	12	28	54
55	39	15	7	5	19	43	67	50	32	16	8	6	20	46	80
103	79	31	21	13	29	59	93	104	58	40	22	14	38	72	94
119	101	61	45	37	77	95	113	120	102	66	48	30	64	96	114
127	117	99	69	53	97	115	125	128	118	100	74	112	98	116	126

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FIG.1

62	53	49	25	38	46	58	63
57	51	29	14	15	34	42	54
45	33	13	6	7	16	30	50
37	21	5	1	2	8	17	26
28	20	12	4	3	9	22	39
52	32	24	11	10	23	35	47
56	44	36	19	18	31	43	59
61	60	48	40	27	51	55	64

FIG.2

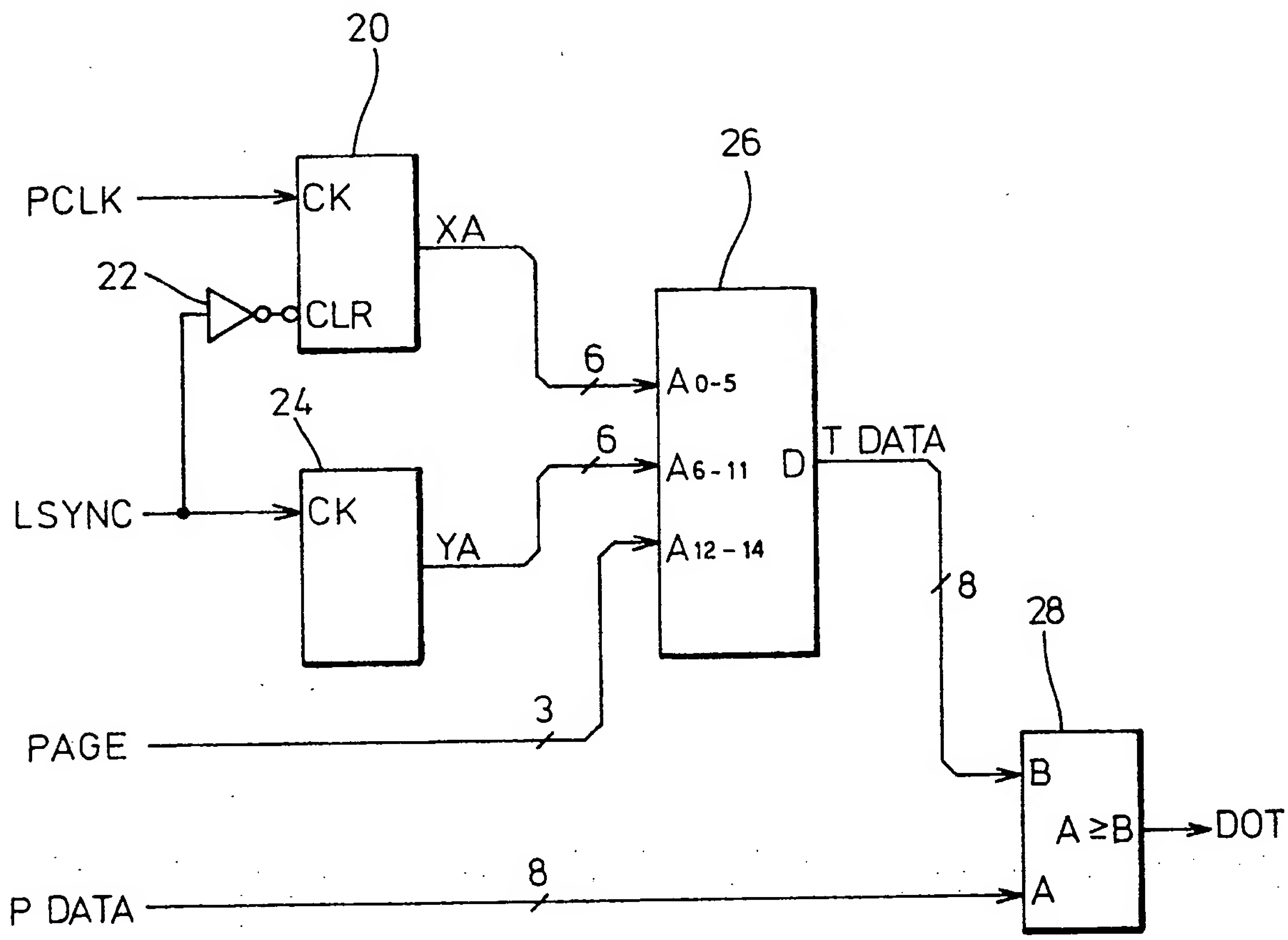
20
26
PCLK
CK
XA
22
CLR
6
A0-5
24
6
A6-11
D
T DATA
LSYNC
CK
YA
A12-14
8
28
PAGE
3
B
A≥B
DOT
P DATA
8
A

FIG.3

121	107	85	49	65	87	109	123	122	108	86	52	78	88	110	124
105	83	73	33	41	57	89	111	106	84	60	26	44	70	90	112
81	63	25	9	17	27	75	91	82	68	34	10	18	36	62	92
71	47	23	1	3	11	35	51	76	42	24	2	4	12	28	54
55	39	15	7	5	19	43	67	50	32	16	8	6	20	46	80
103	79	31	21	13	29	59	93	104	58	40	22	14	38	72	94
119	101	61	45	37	77	95	113	120	102	66	48	30	64	96	114
127	117	99	69	53	97	115	125	128	118	100	74	112	98	116	126

FIG. 4

YA \ XA	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	242	214	170	98	130	174	218	246	244	216	172	104	156	176	220	248
1	210	166	146	66	82	114	178	222	212	168	120	52	88	140	180	224
2	162	126	50	18	34	54	150	182	164	136	68	20	36	72	124	184
3	142	94	46	2	6	22	70	102	152	84	48	4	8	24	56	108
4	110	78	30	14	10	38	86	134	100	64	32	16	12	40	92	160
5	206	158	62	42	26	58	118	186	208	116	80	44	28	76	144	188
6	238	202	122	90	74	154	190	226	240	204	132	96	60	128	192	228
7	254	234	198	138	106	194	230	250	256	236	200	148	112	196	232	252

FIG. 5

YA \ XA	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	242	214	170	98	130	174	218	246	244	216	172	104	156	176	220	248
1	210	166	146	66	82	114	178	222	212	168	120	52	88	140	180	224
2	162	126	50	18	34	54	150	182	164	136	68	20	36	72	124	184
3	142	94	46	2	6	22	70	102	152	84	48	4	8	24	56	108
4	110	78	30	14	10	38	86	134	100	64	32	16	12	40	92	160
5	206	158	62	42	26	58	118	186	208	116	80	44	28	76	144	188
6	238	202	122	90	74	154	190	226	240	204	132	96	60	128	192	228
7	254	234	198	138	106	194	230	250	256	236	200	148	112	196	232	252

SPECIFICATION

Method of forming halftone dots

BACKGROUND OF THE INVENTION

The present invention relates to a method of forming halftone dots in a platemaking scanner, and more particularly to a halftone-dot forming method utilizing a template memory having a threshold pattern with a plurality of predetermined minute points (referred to half-tone-dot elements) for forming halftone dots.

Reproduced halftone-dot images are smoother in outlines and more detailed as the number of halftone dots per unit length, i.e., the screen ruling, is greater. As disclosed in Japanese Laid-Open Patent Publication No. 60 (1985)-132465, for example, each halftone dot comprises a plurality of divided minute grid elements. It is however difficult to reduce the area of each of the grid elements below a certain size due to optical or mechanical limitations. Even if the area of each grid element were made smaller than such a certain size, it would take a considerable time to convert the halftone dots to black dots. Since it would be quite time-consuming to obtain a desired image, the area of each grid element is limited of necessity. Where it is desired to reproduce an image with a wide range of gradations of tone, a halftone-dot forming template may be employed which has many grid elements per halftone dot. The greater the number of grid elements in one halftone dot, however, the smaller the screen ruling becomes, making it more difficult to reproduce an image with a smoother outline and greater image detail. Conversely, the greater the screen ruling, the smaller the number of minute grid elements making up a halftone dot, resulting in an insufficient number of gradations of tone.

FIG. 1 of the accompanying drawings illustrates a conventional threshold pattern template for forming a halftone dot. The threshold pattern template can produce 64 gradations (1, 2, ..., 64) of tone. The threshold pattern template has a plurality of minute grid elements with respective threshold levels being expressed by respective numerals. When an image signal having a level higher than the indicated threshold level of a grid element is applied to a halftone dot generator, the generator produces a halftone-dot blackening signal to blacken the grid element. When an image signal having a level lower than the indicated threshold level of a grid element is applied to the halftone dot generator, the grid element is not blackened. The threshold levels of the respective grid elements become lower toward the center of the dot region and higher toward the outer edge of the dot region.

It has been conventional practice to employ as many such templates combined together as desired to meet the size of an original image, to form a desired image. The formed image has gradations of tone which do not exceed in number the gradations of each halftone dot of the reproduced image, i.e, 64 gradations of tone.

SUMMARY OF THE INVENTION

The present invention results from studies to provide a method of forming halftone dots by employing a template memory capable of reproducing detailed and sufficient gradations of tone even if the screen ruling is large.

One aspect of the present invention provides a method of forming halftone dots by employing a halftone-dot forming template having a plurality of divided minute grid elements with respective predetermined threshold levels assigned thereto, and comparing the signal level of an image signal with the threshold level of each of the grid elements, the method comprising the steps of provding a composite halftone-dot forming template composed of two or more (*n*) of the halftone-dot forming template arranged side by side, and varying one of the *n* threshold pattern templates of the composite halftone-dot forming template according to a change in the level of the image signal commensurate with one threshold gradation of the composite halftone-dot forming template.

Another aspect of the present invention provides a method of forming halftone dots, wherein the threshold levels of the respective grid elements of the composite halftone-dot forming template are of different values from each other, those grid elements the difference between which corresponds to one threshold gradation belonging to different ones, respectively, of the the halftone-dot forming templates.

The above and other features and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings in which a preferred embodiment of the present invention is shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram showing a halftone-dot forming template having 64 threshold levels;

FIG. 2 is a block diagram of an arrangement for carrying out a method according to the present invention;

FIG. 3 is a diagram of a halftone-dot forming template having 128 threshold levels, which can be employed in the method of the present invention;

FIG. 4 is a diagram of a halftone-dot forming template for an image signal having 8 bits = 256 gradations of tone, which can be employed in the method of the present invention; and

FIG. 5 is a diagram showing a halftone-dot

blacked by the method of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 2 shows in block form an arrangement for carrying out a halftone-dot forming method of the present invention. In FIG. 2, the arrows directed to and away from various components or blocks of the arrangement indicate the directions in which signals flow, and the lines with respective single short slanting lines accompanied by nearby numerals Z (= 3, 6, 8) represent Z-bit signal lines. An X counter 20 for counting pixels in a main scanning direction X of a halftone-dot forming template comprises a programmable modulo-N counter. A Y counter 24 for counting pixels in a subscanning direction Y of a halftone-dot forming template comprises a programmable modulo-M counter. The X counter 20 has a clock input terminal CK supplied with pixel clock pulses PCLK each generated per pixel, and an initializing terminal CLR to which a line synchronizing signal LSYNC is applied via an inverter 22. The line synchronizing signal LSYNC is also applied to a clock input terminal CK of the Y counter 24.

The X counter 20 produces 6-bit address data XA as output data which is applied to an address input terminal $A_{0\text{-}5}$ of a template memory 26. The Y counter 24 produces 6-bit address data YA as output data which is applied to an address input terminal $A_{6\text{-}11}$ of the template memory 26. The template memory 26 has another address input terminal $A_{12\text{-}14}$ which is supplied with a page selection signal PAGE.

The template memory 26 produces as an output signal 8-bit template data TDATA that is applied to an input terminal B of a comparator 28, with its other input terminal A being supplied with an image data signal PDATA from an 8-bit A/D converter (not shown). The comparator 28 produces a halftone-dot blackening signal which is sent to a halftone-dot generator (not shown).

Operation and advantages of the arrangement, thus constructed, for carrying out the halftone-dot forming method will be described with reference to FIGS. 3 through 5.

FIG. 3 shows, by way of example, a halftone-dot forming template for forming halftone dots before they are blackened which are formed by the halftone-dot forming method. The template has a size equal to the combined size of two templates, arranged horizontally side by side, each of which is equivalent to the conventional template illustrated in FIG. 1. The halftone-dot forming template is characterized in the order or sequence of threshold levels assigned to the respective minute grid elements of the template. The pattern of threshold levels in each of the righthand and such that the threshold levels of the respective grid elements become lower toward the center of the dot region and higher toward the outer edge of the dot region, as with the conventional pattern shown in FIG. 1. However, the successive threshold levels are allotted alternately to the righthand and lefthand halves of the template, as can easily be understood by confirming the numerals in the grid elements of FIG. 3. Halftone dots formed by using the halftone-dot forming threshold pattern template shown in FIG. 3 can have 128 gradations of tone, for example, which are twice the 64 gradations of tone produced even if two of the conventional halftone-dot forming threshold pattern template shown in FIG. 1 are arranged side by side.

The line synchronizing signal LSYNC shown in FIG. 2 is a pulse indicating the starting of one scanning line in the main scanning line X. The pixel clock pulse signal PCLK is a clock pulse corresponding to one pixel. The template data signal TDATA is a threshold signal which is produced in synchronism with the pixel clock signal PCLK. As described above, the X counter 20 and the Y counter 24 are programmable modulo-N and modulo-M counters, respectively, and are set to the sizes (the number of pixels) of the threshold pattern template in the main scanning direction X and the subscanning direction Y. For example, where the threshold pattern template contains 16 pixels in the main scanning direction and 8 pixels in the subscanning direction, the X counter 20 is set as a modulo-16 counter, and the Y counter 24 as a modulo-8 counter. The page selection signal PAGE is a signal representative of which type of template is to be used among a plurality of templates stored in the template memory 26. A suitable template type is selected by the page selection signal PAGE according to the characteristics of a photoelectric transducer for scanning an original image to read the same, the screen ruling, the screen angle, and other factors. As an example, FIG. 4 shows a threshold pattern template for forming a halftone-dot template to be blackened by the 8-bit image data PDATA shown in FIG. 2. The threshold gradation between one threshold level and a next threshold level is predetermined as 2/256. The threshold pattern template is prepared in the template memory 26 so as to be output therefrom, by being addressed by the page selection signal PAGE. The X counter 20 is initialized by the line synchronizing signal LSYNC (address data XA = 0), and applies address data XA in the X direction of the template to the address input terminal $A_{0\text{-}5}$ of the template memory 26 in each cycle of 16 pixels. Address data in the Y direction of the template is now updated during one scanning period. With the page selection signal PAGE and the address data XA, YA being used as

relative to the threshold level of each grid element of hte halftone-dot forming threshold pattern template is issued from the template memory 26, and then compared with an image signal PDATA by the comparator 28, which then sends a halftone-dot blackening signal DOT to the non-illustrated halftone dot generator.

The threshold levels of the respective grid elements of the threshold pattern template memory 26 correspond to 8 bits = 256 (the threshold levels are incremented by a 2/256 threshold gradation). Therefore, if 35 (obtained as a result of conversion from 8-bit data to a decimal number) is applied as the image signal PDATA to the comparator 28, the comparator 28 compares the numeral 35 successively with the threshold levels of the grid elements according to the sequence of the address data.

Now, A = 35 and B = a threshold level at the input terminals of the comparator 28. When $A \geqq B$, i.e., $35 \geqq$ threshold level, a halftone-dot blackening signal DOT is generated by the comparator 28 for producing a blackened halftone-dot template as shown in FIG. 5.

While the number of minute grid elements of the halftone-dot forming template is 128 in the illustrated embodiment, a halftone-dot forming template with a smaller number of minute grid elements than 128 may be employed, and in such a case, two or more grid elements of the halftone-dot forming template may have an identical threshold level.

With the method of the present invention, as described above, there are provided two or more *n* threshold pattern templates arranged side by side for forming halftone dots, and one of the *n* combined threshold pattern templates is varied according to one threshold gradation change in an image signal. Therefore, a composite halftone-dot forming template is constructed which has gradations of tone that are *n* times the number of grid elements of each of the *n* halftone-dot forming templates.

A composite halftone-dot forming template may comprise a vertical array of halftone-dot forming templates.

Although a certain preferred embodiment has been shown and described, it should be understood that many changes and modifications may be made therein without departing from the scope of the appended claims.

CLAIMS

1. A method of forming halftone dots by employing a halftone-dot forming template having a plurality of divided minute grid elements with respective predetermined threshold levels assigned thereto, and comparing the signal level of an image signal with the threshold level of each of the grid elements, said provding a composite halftone-dot forming template composed of two or more (*n*) of said halftone-dot forming template arranged side by side; and

varying one of the *n* threshold pattern templates of said composite halftone-dot forming template according to a change in the level of said image signal commensurate with one threshold gradation of said composite halftone-dot forming template.

2. A method according to claim 1, wherein the threshold levels of the respective grid elements of said composite halftone-dot forming template are of different values from each other, those grid elements the difference between which corresponds to one threshold gradation belonging to different ones, respectively, of the said halftone-dot forming templates.

3. A method according to claim 1 substantially as described herein with reference to Figures 2, 3 or 4 of the accompanying drawings.

4. A halftone-dot image obtained by employing a method as claimed in any one of claims 1 to 4.

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